TOTAL MAXIMUM DAILY LOADS (TMDLs)

For
Chlordane
And Polychlorinated Biphenyls (PCBs)
In The
Wolf River

Wolf River Watershed (HUC 08010210)

Shelby County, Tennessee

FINAL

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TABLE OF CONTENTS

APPENDICES

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

ADB	Assessment Database
BCF	Bioconcentration Factor
BMP	Best Management Practices
CFR	Code of Federal Regulations
HUC	Hydrologic Unit Code
LA	Load Allocation
MOS	Margin of Safety
MRLC	Multi-Resolution Land Characteristic
MS4	Municipal Separate Storm Sewer System
NHD	National Hydrography Dataset
NPL	National Priorities List
NPS	Non-point Source
NPDES	National Pollutant Discharge Elimination System
PCB	Polychlorinated Biphenyl
PPB	Parts per Billion
PPM	Parts per Million
RM	River Mile
STP	Sewage Treatment Plant
TDA	Tennessee Department of Agriculture
TDEC	Tennessee Department of Environment & Conservation
TMDL	Total Maximum Daily Load
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
WLA	Waste Load Allocation
WWTF	Wastewater Treatment Facility

SUMMARY SHEET

WOLF RIVER (HUC 08010210)

Total Maximum Daily Loads for Chlordane and Polychlorinated Biphenyls (PCBs) as Identified on the State of Tennessee's *2006 303(d) List*

Impaired Waterbody Information:

State: Tennessee
County: Shelby
Watershed: Wolf River Watershed (HUC 08010210)
Constituents of Concern: Chlordane and Polychlorinated Biphenyls (PCBs)

Waterbody ID	Impaired Waterbody	Miles/Ac
TN08010210001_1000	Wolf River	12.8
TN08010210002_1000	Wolf River	6.3

Designated Uses:	Fish & aquatic life, industrial water supply, irrigation, livestock watering & wildlife, navigation, and recreation.
Applicable Water Quality Standard (Chlordane):	Most stringent numerical criteria applicable to fish & aquatic life use classification.
Toxic Substances (Chlordane):	The waters shall not contain substances or a combination of substances including disease-causing agents which, by way of either direct exposure or indirect exposure through food chains, may cause death, disease, behavioral abnormalities, cancer, genetic mutations, physiological malfunctions (including malfunctions in reproduction), physical deformations, or restrict or impair growth in fish or aquatic life or their offspring.
Applicable Water Quality Standard (PCBs):	Most stringent numerical criteria applicable to recreation use classification.
Toxic Substances (PCBs):	The waters shall not contain toxic substances, whether alone or in combination with other substances, that will render the waters unsafe or unsuitable for water contact activities including the capture and subsequent consumption of fish and shellfish, or will propose toxic conditions that will adversely affect man, animal, aquatic life, or wildlife. Human health criteria have been derived to protect the consumer from consumption of contaminated fish and water. The water and organisms criteria should only be applied to those waters classified for both recreation and domestic water.

TMDL Development

General Analysis Methodology:

- Composite fish tissue samples were collected and analyzed for constituents of concern. Concentrations of chlordane and PCBs in the water column are estimated from the fish tissue concentrations using the Bioconcentration Factors defined by the U.S. Environmental Protection Agency.

- The target loads are based on the product of the summer low flow and the water quality criteria established by the Tennessee Department of Environment and Conservation, Division of Water Pollution Control.

- Waste Load Allocations (WLAs) are derived for point source dischargers of chlordane and/or PCBs.

- Load Allocations are established for non-point sources using a mass-balance approach.

Critical Conditions: Methodology takes into account all flow conditions.

Seasonal Variation: Methodology addresses all seasons.

Margin of Safety (MOS): 20% (Explicit).

TMDLs/Allocations

Waterbody ID	Impaired Waterbody	Pollutant	TMDL	WLA	LA	MOS	*Required Load Reduction**
			[g/day]	[g/day]	[g/day]	[g/day]	*[%]*
TN08010210001_1000	Wolf River	Chlordane	2.20	N/A	1.76	0.44	*0.0*
		PCBs	0.38	N/A	0.30	0.08	*95.4*
TN08010210002_1000	Wolf River	Chlordane	2.22	N/A	1.78	0.44	*0.0*
		PCBs	0.35	N/A	0.28	0.07	*95.5*

*Note: Load reduction required to achieve TMDL.

TOTAL MAXIMUM DAILY LOADS (TMDLs) FOR CHLORDANE AND PCBs WOLF RIVER (HUC 08010210)

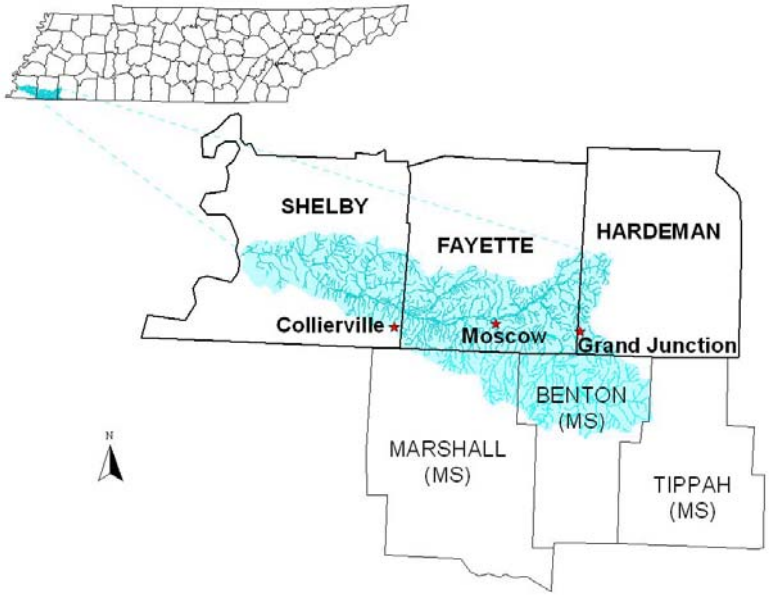
1.0 INTRODUCTION

Section 303(d) of the Clean Water Act requires each state to list those waters within its boundaries for which technology-based effluent limitations are not stringent enough to protect any water quality standard applicable to such waters. Impaired waters are prioritized with respect to designated use classifications and the severity of pollution. In accordance with this prioritization, states are required to develop Total Maximum Daily Loads (TMDLs) for those waterbodies that are not attaining water quality standards. State water quality standards consist of designated use(s) for individual waterbodies, appropriate numeric and narrative water quality criteria protective of the designated uses, and an antidegradation statement. The TMDL process establishes the maximum allowable loadings of pollutants for a waterbody that will allow the waterbody to maintain water quality standards. The TMDL may then be used to develop controls for reducing pollution from both point and non-point sources in order to restore and maintain the quality of water resources (USEPA, 1991).

2.0 WATERSHED DESCRIPTION

The Wolf River Watershed, Hydrologic Unit Code (HUC) 08010210, is located in Mississippi and southwestern Tennessee (ref.: Figure 1). The information (including figures and tables) presented hereafter in this document is for the Tennessee portion of the watershed only.

Figure 1 Location of the Wolf River Watershed



The Wolf River Watershed includes parts of Fayette, Hardeman, and Shelby counties in Tennessee. The watershed lies within three Level III ecoregions (Southeastern Plains, Mississippi Alluvial Plain, and Mississippi Valley Loess Plains) and contains three Level IV subecoregions (USEPA, 1997) as shown in Figure 2.

Figure 2 Level IV Ecoregions in the Wolf River Watershed

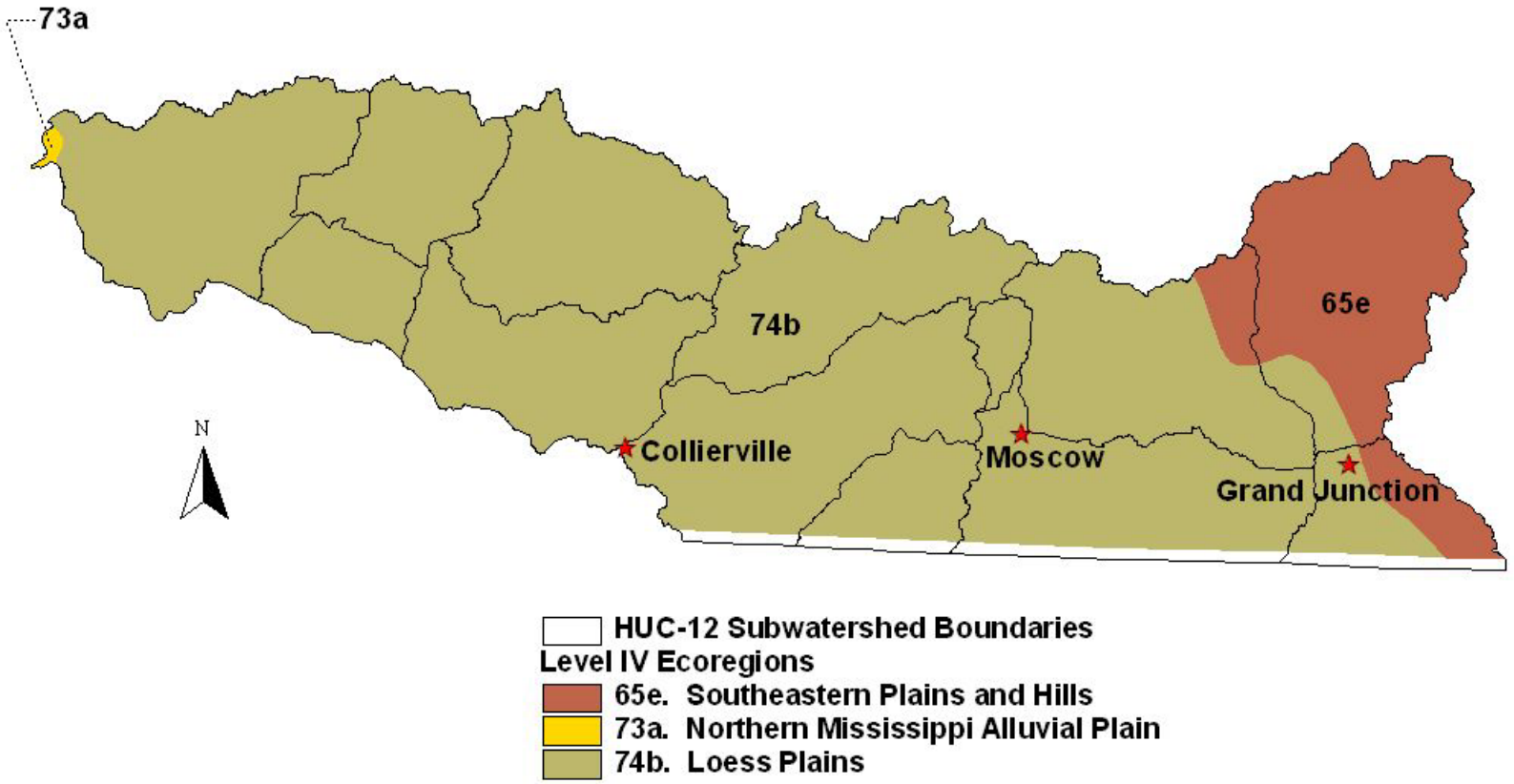


Table 1 Land Use Distribution – Wolf River Watershed

Land Use	Area		[% of watershed]
	[acres]	[mi^2]	
Bare Rock/Sand/Clay	137	0.21	0.04
Deciduous Forest	87,657	136.96	24.07
Emergent Herbaceous Wetlands	1	0.00	0.00
Evergreen Forest	8,551	13.36	2.35
High Intensity Commercial/Industrial/Transportation	6,488	10.14	1.78
High Intensity Residential	17,348	27.11	4.76
Low Intensity Residential	32,151	50.24	8.83
Mixed Forest	25,335	39.59	6.96
Open Water	5,121	8.00	1.41
Other Grasses	3,973	6.21	1.09
Pasture/Hay	76,040	118.81	20.88
Quarries/Strip Mines/Gravel Pits	108	0.17	0.03
Row Crops	65,091	101.70	17.87
Transitional	1,690	2.64	0.46
Woody Wetlands	34,469	53.86	9.47
Total	**364,160**	**569.00**	**100.00**

Note: A spreadsheet was used for this calculation and values are approximate due to rounding.

The Tennessee portion of the Wolf River Watershed has approximately 1,026 miles of streams and 177 reservoir/lake acres (based on the USEPA/TDEC Assessment Database (ADB)) and drains approximately 569 square miles to the Mississippi River. Land use distribution is based on the 1992 Multi-Resolution Land Characteristic (MRLC) satellite imagery databases. Table 1 summarizes land use for the Wolf River Watershed as shown in Figure 3.

3.0 PROBLEM DEFINITION

The designated use classifications for the Wolf River include fish & aquatic life, industrial water supply, irrigation, livestock watering & wildlife, navigation, and recreation. The State of Tennessee's *2006 303(d) List* (TDEC, 2006) identified two segments of the Wolf River (TN08010210001_1000 and TN08010210002_1000) in the Wolf River Watershed as not fully supporting designated use classifications due, in part, to elevated levels of chlordane and polychlorinated biphenyls (PCBs) in fish tissue samples. Contaminated sediment has been identified as the source of pollutant causes associated with both impairments. The 2006 303(d) listing for the impaired sections of the Wolf River are summarized in Table 2 and the waterbodies are shown in Figure 4. Assessment information excerpted from the Assessment Database (ADB) is also listed in Table 2. ADB information may be accessed at:

http://gwidc.memphis.edu/website/dwpc/

Figure 3 Land Use in the Wolf River Watershed

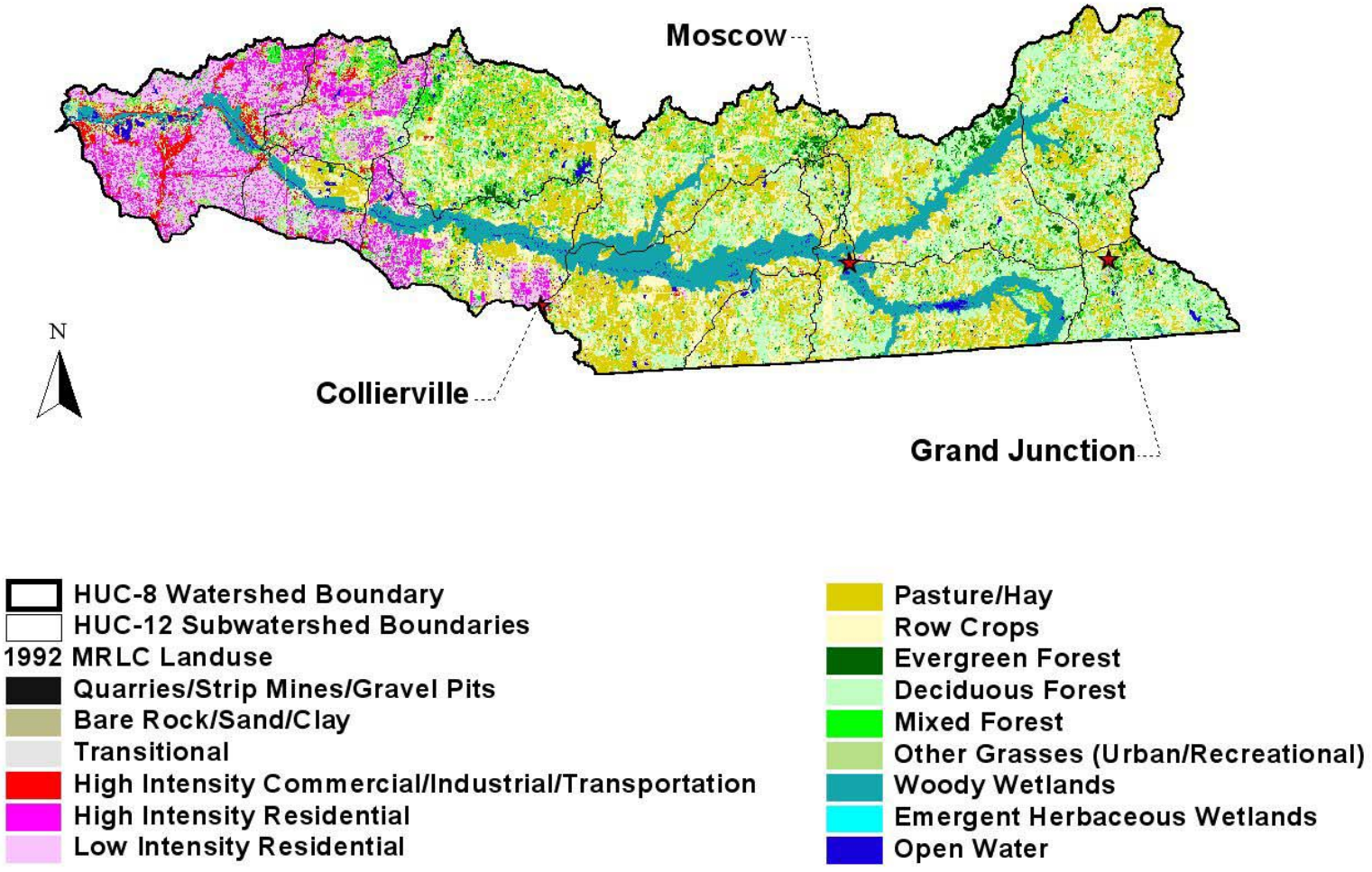


Figure 4 Location of the Wolf River Chlordane and PCB Impairments (Documented on the *2006 303(d) List*)

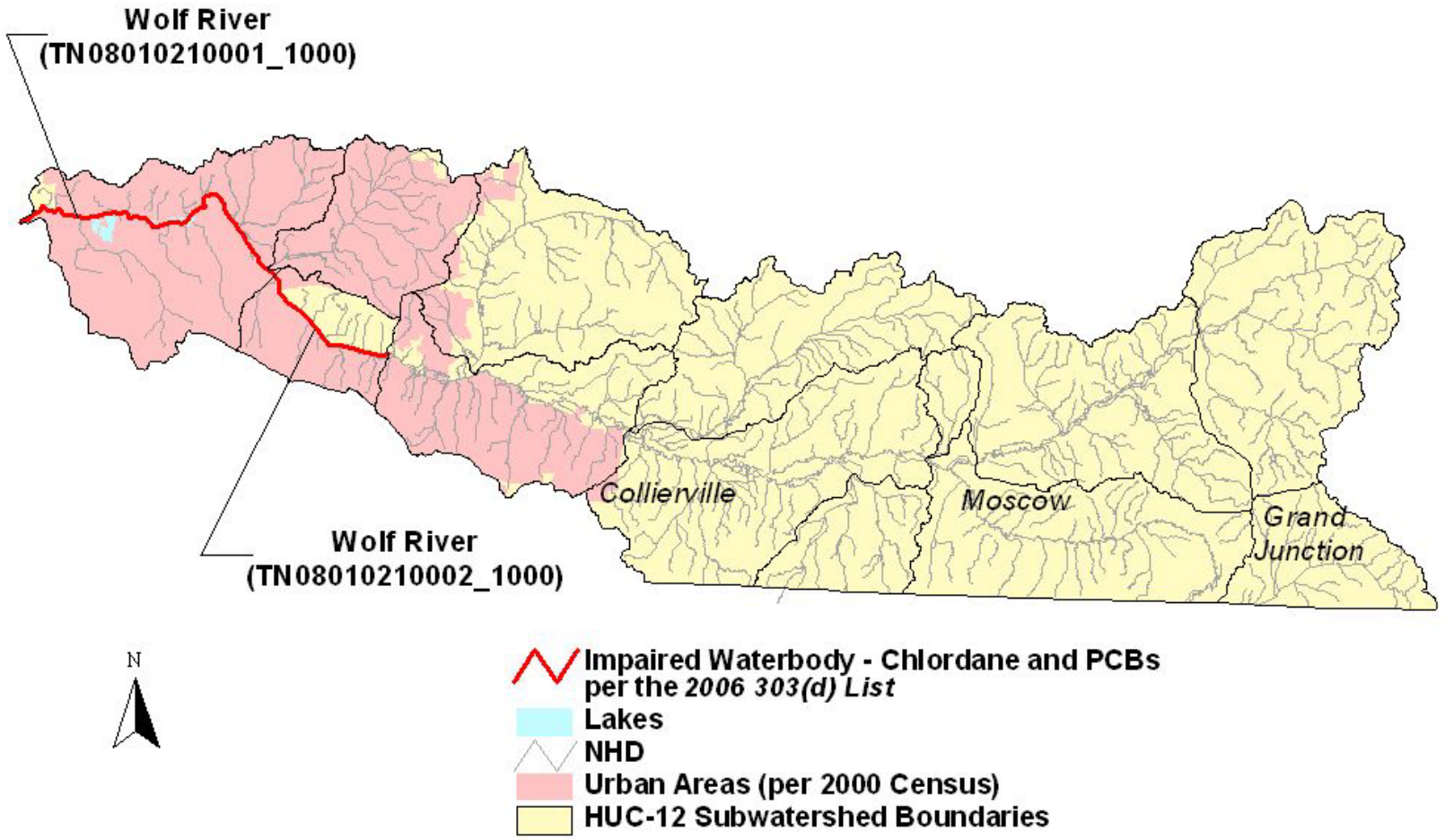


Table 2 *2006 303(d) List* - Stream Impairment Due to Chlordane and PCBs

Waterbody ID	Waterbody	Miles/ Acres	Cause (Pollutant)	Source (Pollutant)	Assessment Comments
TN08010210001_1000	Wolf River (from Mississippi River to Fletcher Creek)	12.8	Lead Chlordane PCBs Dioxin Loss of biological integrity due to siltation Escherichia coli	Discharges from MS4 area RCRA Hazardous Waste Site Channelization Contaminated sediments	Fishing Advisory TDEC ambient chemical station at mile 1.5 (U.S. Highway 51) and at mile 9.3 (Austin Peay Highway). At mile 1.5: 11 out of 37 E.coli observations over 941. One low DO. Suspended residue levels elevated - many over 100. Total phosphorus also elevated. At mile 9.3: 7 out of 24 E.coli observations over 941. Suspended residue and phosphorus elevated. Lead elevated - Ross Metals Superfund site upstream.
TN08010210002_1000	Wolf River (from Fletcher Creek to Grays Creek)	6.3	Chlordane PCBs Dioxin Lead Loss of biological integrity due to siltation Escherichia coli	RCRA Hazardous Waste Site Contaminated Sediments Channelization Discharges from MS4 area	Fishing Advisory. TDEC ambient chemical station at mile 18.9 (Germantown Parkway). 3 out of 24 E.coli observations over 941. Suspended residue and phosphorus elevated. 5 out of 23 observations of lead exceed chronic criteria. Ross Metals Superfund site upstream.

3.1 Chlordane

Chlordane is a synthetic, chlorinated organic compound with broad applications as an insecticide. Pure chlordane is a mixture of stereoisomers primarily in the cis (alpha) and trans (gamma) forms. Technical grade chlordane, on the other hand, is a formulary of various chlorinated hydrocarbons (e.g. heptachlor, chlordene, and nonachlor) in addition to the cis and trans isomers. Chlordane was widely used in the United States for termite control and as an insecticide for agricultural crops, home lawns, and gardens. Due to rising concerns over the product's safety, however, the U.S. Environmental Protection Agency began to restrict the use of chlordane on food crops, lawns, and gardens as early as 1978.

Chlordane is an environmentally persistent and bioaccumulative substance, which has been classified as a probable human carcinogen. Although it can still be manufactured in the United States, the Environmental Protection Agency canceled commercial use of chlordane in 1988. Large amounts of chlordane were already widely distributed throughout the environment by the time its usage ended. According to *Toxicological Review of Chlordane* (USEPA, 1997a), "[Chlordane] residues still exist in soils and sediments and chlordane bioaccumulates in fatty tissue of fish and humans; this bioaccumulation is a source of current concern."

3.2 Polychlorinated Biphenyls (PCBs)

PCBs are a group of 209 distinct chlorinated biphenyl compounds. These 209 synthetic organic compounds vary not only in their physical and chemical properties, but also in toxicity (USEPA, 1999). PCBs exist as individual congeners or in the form of commercial mixtures known as Aroclors. Due to their chemical stability, polychlorinated biphenyls were used in a variety of commercial practices especially electrical and heat transfer processes.

PCBs were legally manufactured in the United States until the U.S. Environmental Protection Agency banned their production in 1979. Prior to this ban, PCBs were commonly used in transformers, capacitors, coatings, adhesives, and an assortment of other products. The manufacturing ban on PCBs did not require all PCB-containing materials to be removed from use. Therefore, some PCBs may still be utilized commercially. Before strict disposal regulations were established, large amounts of PCBs were discarded improperly. So, although the production of PCBs has ceased, these chemicals are widely distributed throughout the environment.

As stated in *Fact Sheet: Polychlorinated Biphenyls Update: Impact on Fish Advisories* (USEPA, 1999):

> Currently, the major source of PCBs is environmental reservoirs from past releases. PCBs have been detected in soil, surface water, air, sediment, plants, and animal tissue in all regions of the earth. PCBs are highly persistent in the environment with reported half-lives in soil and sediment ranging from months to years.

Once in the sediment, PCBs can enter the aquatic food chain. PCBs are fat-soluble chemicals with the potential to concentrate in fish tissue. As a result, humans may be exposed to PCBs through the consumption of contaminated foods, primarily contaminated fish. Studies have demonstrated adverse health effects resulting from PCB exposure. PCBs are classified as

probable human carcinogens and among other things have been shown to be toxic to the immune system, the reproductive system, the nervous system, and the endocrine system.

To protect fish consumers, the Tennessee Department of Environment and Conservation, Division of Water Pollution Control currently issues 2 types of fish consumption advisories. A "do not consume" advisory targets the general population and warns that no one should eat specific fish from a particular body of water. The "precautionary advisory" specifies that atypical consumers (those who are more sensitive to contaminated fish consumption) should not consume the fish species named, and all other people should limit consumption to one meal per month (TDEC, 2004). A do not consume advisory is posted for the impaired segments of the Wolf River.

4.0 TARGET IDENTIFICATION

These TMDLs are being proposed for two segments of the Wolf River, which are impaired because chlordane and PCBs in fish tissue samples were detected at levels that exceed the plausible-upper-limit carcinogenic risk (ref.: Appendix B). In order for a TMDL to be established, a numeric "target" protective of the uses of the water must be identified to serve as the basis for the TMDL. Numerical criteria, applicable for chlordane and PCBs, have been established in *Rules of Tennessee Department of Environment and Conservation, Tennessee Water Quality Control Board, Division of Water Pollution Control, Chapter 1200-4-3 General Water Quality Criteria, January 2004* (TDEC, 2004) to preserve the various use classifications.

4.1 Chlordane Target

The fish & aquatic life designated use classification will provide the basis for the chlordane TMDLs. While numerical criteria also exist under the recreation designated use, TMDLs developed to protect fish & aquatic life will protect all other use classifications for the identified waterbodies from adverse effects due to chlordane loading. Under the fish & aquatic life designated use classification, the Tennessee water quality criterion continuous concentration (CCC) for chlordane is 0.0043 µg/L and the criterion maximum concentration (CMC) is 2.4 µg/L. Due to the bioaccumulative nature of the chlordane impairment, the more stringent continuous concentration criterion will serve as the appropriate target for the TMDLs.

4.2 PCB Target

The recreation designated use classification will provide the basis for the PCB TMDLs. While numerical criteria also exist under the fish & aquatic life designated use, TMDLs developed to protect recreation will protect all other use classifications for the identified waterbodies from adverse alteration due to PCB loading. The Tennessee water quality criteria for individual PCB Aroclors and total PCBs are both 0.00064 µg/L under the recreation designated use classification (ref.: Appendix B). This value is the same for organism only and water & organism consumption. So, 0.00064 µg/L will serve as the appropriate target for the PCB TMDLs.

5.0 WATER QUALITY ASSESSMENT AND DEVIATION FROM TARGET

Fish tissue samples were collected from the sites shown in Figure 5. According to the methodology outlined in Section 7.1, the water column concentrations and the existing loads of chlordane and PCBs in the water column were predicted from composite fish tissue data.

5.1 Chlordane Water Quality Assessment and Deviation

Using fish tissues samples collected from the impaired segments of the Wolf River, the concentrations of chlordane in the water column were estimated through the Bioconcentration Factor defined by the U.S. Environmental Protection Agency (ref.: Appendix A). The existing water column concentrations were based on the fish species recording the highest concentrations (ref.: Table 3). Fish tissue data was only available from a sampling site on one segment of the Wolf River (waterbody ID TN0801210001_1000); therefore, records from that sampling site were used to calculate the concentrations of chlordane in both of the impaired segments. The amount of chlordane in these parts of the Wolf River was estimated to be 0.002 µg/L, which is less than the 0.0043 µg/L target value.

5.2 PCBs Water Quality Assessment and Deviation

The existing concentrations of PCBs in each segment of the water column were also estimated through the Bioconcentration Factor defined by the U.S. Environmental Protection Agency (ref.: Appendix B). This data is presented in Table 4. The availability of composite fish tissue samples again limited the range of data used to calculate the average fish tissue concentrations. Therefore, the concentrations of PCBs in both of the impaired segments of the Wolf River were estimated from data collected at the same sampling site. Accordingly, the water column concentrations of PCBs were projected to be 0.014 µg/L, which is greater than the 0.00064 µg/L target value.

Table 3 Existing Concentration of Chlordane in the Wolf River Predicted from Fish Tissue Samples

Fish Species	Sample Year	Sampling Site Location	Total Chlordane in Fish Sample (ppm)	Calculated Water Column Concentration (µg/L)
Carp Sucker	2006	Highway 51	0.119	0.002
Channel Catfish			0.048	0.001

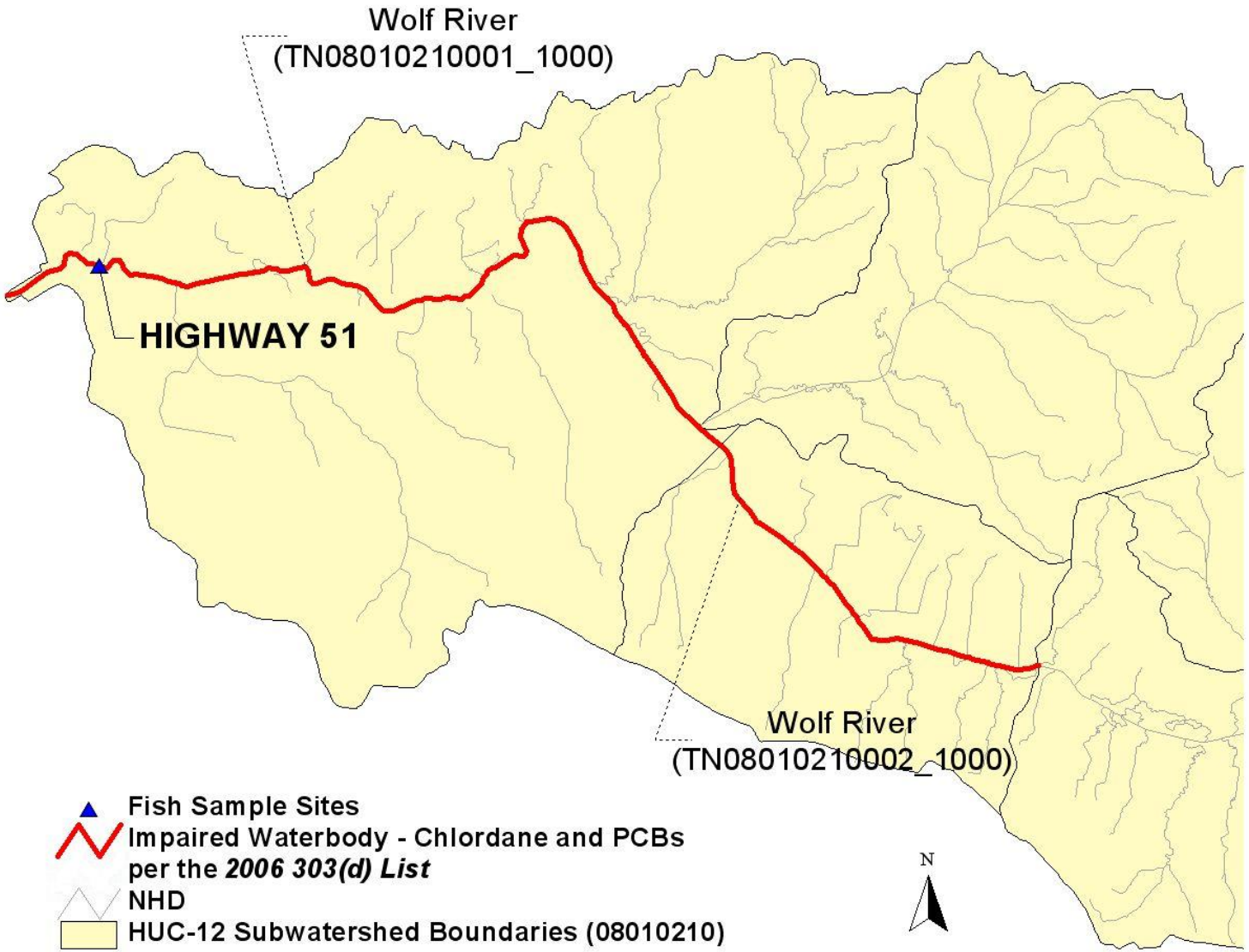
Note: Total chlordane was calculated as the sum of alpha chlordane, gamma chlordane, cis-nonachlor, and trans-nonachlor.

Table 4 Existing Concentration of PCBs in the Wolf River Estimated from Fish Tissue Samples

Fish Species	Sample Year	Sampling Site Location	Total PCBs in Fish Sample (ppm)	Calculated Water Column Concentration (µg/L)
Carp Sucker	2006	Highway 51	0.45	0.014
Channel Catfish			0.32	0.010
White Bass			0.41	0.013

Note: Data presented is representative of PCB Aroclor 1260 – other Aroclors may have been below detection limits.

Figure 5 Sample Collection Sites along the Wolf River



6.0 SOURCE ASSESSMENT

An important part of the TMDL analysis is the identification of individual sources, source categories, or source subcategories of pollutants in the watershed and the amount of pollutant loading contributed by each of these sources. According to the Clean Water Act, sources are broadly classified as either point or non-point sources. Under 40 CFR §122.2, a point source is defined as a discernable, confined, and discrete conveyance from which pollutants are or may be discharged to surface waters. The National Pollutant Discharge Elimination System (NPDES) program regulates point source discharges. Regulated point sources include: 1) municipal and industrial wastewater treatment facilities (WWTFs); 2) storm water discharges associated with industrial activity (which includes construction activities); and 3) certain discharges from Municipal Separate Storm Sewer Systems (MS4s). For the purposes of these TMDLs, all sources of pollutant loading not regulated by NPDES are considered non-point sources.

6.1 Point Sources

There are numerous permitted dischargers in the Wolf River Watershed. However, there are currently no permitted point source dischargers with existing allocations for chlordane or PCBs.

6.2 Non-point Sources

Assessments have named contaminated sediment as the source of chlordane and PCB impairments in two segments of the Wolf River. Ross Metals Inc. hazardous waste site (TND096070396) is located upstream of these impaired waterbodies, but according to references compiled by the U.S. Environmental Protection Agency, the site has not been associated with chlordane or PCB contamination.

On the other hand, North Hollywood Dump (TND980558894) in Shelby County was identified as a hazardous waste site noted for chlordane contamination. The site was used as a municipal dump from the 1930s until it was closed in 1967. During its operation industrial wastes from the former Hayden Chemical Company (which was purchased by Velsicol Chemical Corporation) were disposed of at this site. Velsicol Chemical Corporation, historically a major producer of chlordane, also disposed of industrial wastes at North Hollywood Dump - including “pesticide-contaminated sludge” (USEPA, 2007). The site was added to the NPL in 1983 (USEPA, 1983) and according to the U.S. EPA, pesticide-related compounds and heavy metals were detected on the site, with nearby soils and surface water being contaminated. (USEPA, 1983a). Later investigations confirmed the presence of chlordane (and other contaminants) in the groundwater. Physical cleanup activities at the site have been completed and North Hollywood Dump was removed from the NPL in 1997. However, recreational activity has been restricted and “long term monitoring of groundwater, surface water, and fish will continue” because fish from an onsite pond were found to contain “pesticide levels exceeding cleanup goals” (USEPA, 2007).

North Hollywood Dump was a likely source of historical contamination. So these TMDLs will consider contaminated sediments in the riverbed as the primary source of chlordane and PCBs in the Wolf River. According to the U.S. Environmental Protection Agency, “Because PCBs have very low solubility in water and low volatility, most PCBs are contained in sediments that serve as environmental reservoirs from which PCBs may continue to be released over a long

period of time. PCBs may be mobilized from sediments if disturbed (e.g., flooding, dredging)" (USEPA, 1999).

7.0 DEVELOPMENT OF TOTAL MAXIMUM DAILY LOADS

The TMDL process quantifies the amount of a pollutant that can be assimilated in a waterbody, identifies the sources of the pollutant, and recommends regulatory or other actions to be taken to achieve compliance with applicable water quality standards based on the relationship between pollution sources and in-stream water quality conditions. A TMDL can be expressed as the sum of all point source loads (Waste Load Allocations), non-point source loads (Load Allocations) and an appropriate margin of safety (MOS), which takes into account any uncertainty concerning the relationship between effluent limitations and water quality:

$$TMDL = \Sigma\ WLAs + \Sigma\ LAs + MOS$$

The objective of a TMDL is to allocate loads among all of the known pollutant sources throughout a watershed so that appropriate control measures can be implemented and water quality standards achieved. 40 CFR §130.2 (i) states that TMDLs can be expressed in terms of mass per time, toxicity, or other appropriate measure.

7.1 Analysis Methodology

TMDL analyses were performed at various sites to evaluate waterbodies identified as impaired on the *2006 303(d) List* due to elevated levels of chlordane and PCBs in fish tissue samples. The TMDLs for PCBs in the water column, and the corresponding required load reduction, were calculated according to the following procedure:

- Fish tissue samples were collected and analyzed as defined in *The Results of Fish Tissue Monitoring in Tennessee 1992-1997* (TDEC).

- The geometric mean of the concentrations of PCBs in the fish tissue samples was calculated. If several species were analyzed from the same waterbody, the fish species with the highest geometric mean (ref.: Table 4) was used to estimate the concentration of PCBs in the water column:

$$C_{water} = \frac{C_{fish}}{BCF} \times 1{,}000$$

Where C_{fish}= Fish tissue concentration (mg/kg)
C_{water} = Water column concentration (µg/L)
BCF = Bioconcentration factor (31,200 L/kg)
1,000 = Conversion factor (µg/mg)

- Assuming uniform distribution, the existing PCB load was computed as the product of the summer low flow and the estimated water column concentration (ref.: Section 5.2):

Existing Load = C_{water} x Summer Low Flow x Unit Conversion Factor

- The TMDL for PCBs in the river at any time was calculated as the product of the water quality target concentration (ref.: Section 4.2) and the summer low flow:

$$TMDL = C_{target} \times \text{Summer Low Flow} \times \text{Unit Conversion Factor}$$

- A percent reduction, to aid in implementation, was computed using the existing load and the TMDL:

$$\% \text{ Reduction} = \frac{(\text{Existing Load}) - (\text{TMDL})}{(\text{Existing Load})} \times 100\%$$

- A 20% explicit margin of safety was incorporated into the TMDL.

- Waste load and load allocations were calculated using the TMDL value.

Similar methodology was followed for chlordane. However, in order to fairly compare the existing loads to the TMDL, the chlordane-specific normalized Bioconcentration Factor and default lipid composition (ref.: Appendix A) which were utilized to develop the fish & aquatic life designated use criteria were also used to calculate existing water column concentrations.

7.2 Margin of Safety

There are two methods for incorporating a margin of safety (MOS) into the analysis: a) implicitly incorporate the MOS using conservative model assumptions to develop allocations; or b) explicitly specify a portion of the TMDL as the MOS and use the remainder for allocations. In these TMDLs, a 20% explicit margin of safety was utilized to account for uncertainties.

7.3 Seasonal Variation

Chlordane can persist in the environment for many years and loading is expected to fluctuate according to the stream flow and distribution of rainfall. Theoretically, the concentration of chlordane should be inversely proportional to the volume of water flowing through the river. Determination of chlordane loads using the summer low flow (generally stream flows are lowest during this season) accounts for periods when the chlordane concentrations would be the greatest. Similar logic applies to PCBs, which also persist in the environment for many years. Therefore, the TMDLs will provide year-round protection of water quality standards.

7.4 TMDLs for the Impaired Waterbodies

7.4.1 Chlordane TMDLs

The fish and aquatic life designated use provided the most stringent water quality criteria for chlordane. For this designated use classification, the corresponding summer low flow should be expressed as the 7Q10. Flow rates for the downstream segment of the Wolf River (TN08010210001_1000) were estimated from USGS gage station 07031740. There were not 10 years of approved data so the summer low flow was approximated as the lowest 7-day

average between 1996 and 2003, 209 ft^3/sec. The TMDL was derived as described in Section 7.1:

$$TMDL = 0.0043\ \mu g/L \times 209\ ft^3/sec \times 28.32\ L/ft^3 \times 3600\ sec/hr \times 24\ hr/day \times 10^{-6}\ g/\mu g$$
TMDL = 2.20 g/day

Using the estimated water column concentration specified in Section 5.1, the existing load was calculated:

$$Existing\ Load = 0.002\ \mu g/L \times 209\ ft^3/sec \times 28.32\ L/ft^3 \times 3600\ sec/hr \times 24\ hr/day \times 10^{-6}\ g/\mu g$$
Existing Load = 1.02 g/day

Since the calculated existing load is below the maximum allowable load, no load reduction is necessary for chlordane to satisfy the TMDL for waterbody ID TN08010210001_1000.

7.4.2 PCB TMDLs

Water quality criterion under the recreation designated use provided the most stringent target for PCBs in the Wolf River. The summer low flow applicable to this designated use classification should be expressed as the 30Q5. Data from USGS station 07031740 was utilized to approximate the 30Q5 for the downstream segment of the Wolf River (waterbody ID TN0801210001_1000). Between 1998 and 2003 the 30Q5 summer low flow was 243.7 ft^3/sec. The TMDL was calculated as follows:

$$TMDL = 0.00064\ \mu g/L \times 243.7\ ft^3/sec \times 28.32\ L/ft^3 \times 3600\ sec/hr \times 24\ hr/day \times 10^{-6}\ g/\mu g$$
TMDL = 0.38 g/day

The existing load was calculated from the estimated water column concentration (ref.: Section 5.2):

$$Existing\ Load = 0.014\ \mu g/L \times 243.7\ ft^3/sec \times 28.32\ L/ft^3 \times 3600\ sec/hr \times 24\ hr/day \times 10^{-6}\ g/\mu g$$
Existing Load = 8.35 g/day

The percent reduction based on the TMDL was computed from the existing load and maximum allowable load:

$$\%\ Reduction = \frac{(8.35\ g/day) - (0.38\ g/day)}{(8.35\ g/day)} \times 100\% = 95.4\%$$

Similar calculations were performed for the upstream portion of the Wolf River (TN08010210002_1000). The 7Q10 was calculated using data collected at USGS station 07031650 and the summer low flow between 1995 and 2005 was estimated to be 211 ft^3/sec. The corresponding 30Q5 for deriving the PCB TMDL was approximately 225 ft^3/sec. The TMDLs and corresponding load reductions are listed in Table 5.

The TMDLs represent the maximum mass of chlordane and/or PCBs allowable in the water column on any day. Furthermore, these values assume that the pollutants will be uniformly distributed throughout the waterbodies. Such conditions may or may not exist, and in either

Table 5 TMDLs and Allocations for the Wolf River

Waterbody ID	Impaired Waterbody	Pollutant	TMDL	WLA	LA	MOS	*Required Load Reduction**
			[g/day]	[g/day]	[g/day]	[g/day]	*[%]*
TN08010210001_1000	Wolf River	Chlordane	2.20	N/A	1.76	0.44	*0.0*
		PCBs	0.38	N/A	0.30	0.08	*95.4*
TN08010210002_1000	Wolf River	Chlordane	2.22	N/A	1.78	0.44	*0.0*
		PCBs	0.35	N/A	0.28	0.07	*95.5*

*Note: Load reduction required to achieve TMDL.

case the localized concentrations of these pollutants in the Wolf River should not exceed water quality target values.

7.5 Development of Waste Load Allocations and Load Allocations

7.5.1 Waste Load Allocations

There are currently no permitted point source dischargers with existing allocations for chlordane or PCBs. Zero waste load allocations are being provided.

7.5.2 Load Allocations

The load allocation requires the contribution from non-point sources to be less than or equal to the TMDL target value. In the absence of point sources,

$$LA = TMDL - MOS$$

Incorporating the 20% MOS into the TMDLs further restricts the allowable loads of chlordane and PCBs in the Wolf River. The allocations for the impaired segments of the river are also provided in Table 5.

8.0 IMPLEMENTATION PLAN

8.1 Point Sources

There are currently no NPDES permitted facilities with an existing allocation to discharge chlordane or PCBs to the Wolf River. Waste load allocations can be determined, if needed, once the fish tissue concentrations indicate that the river is no longer impaired for elevated levels of chlordane and/or PCBs.

8.2 Non-point Sources

The Tennessee Department of Environment & Conservation (TDEC) has no direct regulatory authority over most non-point source discharges. Voluntary, incentive-based mechanisms will be used to implement non-point source management measures in order to assure that measurable reductions in pollutant loadings can be achieved for the impaired waterbody.

Two segments of the Wolf River were listed as impaired on the *2006 303(d) List* as not fully supporting designated use classifications due, in part, to elevated levels of chlordane. However, fish tissue samples collected at Highway 51 suggest that the levels of chlordane are below the applicable fish & aquatic life criterion (ref.: Table 3). When calculated according to the human health criterion (TDEC, 2004), the chlordane in the water column is very near the water quality threshold for plausible-upper-limit carcinogenic risk (ref.: Table A-1). Therefore, fish tissue sampling should continue to monitor the level of chlordane in the Wolf River. Future monitoring should include more locations along the Wolf River in order to effectively evaluate potential risks to human health.

Contaminated sediment was named as the likely source for chlordane and PCB contamination in the Wolf River. There are generally two options to prevent chlordane and/or PCBs contained

in the sediment from being released to the river: 1) avoid disturbing the sediment or 2) remediate contaminated sites. If the sediment remains undisturbed, these pollutants should degrade over time. On the other hand, if the sediment in the riverbed must be disturbed, remediation efforts will be necessary to control the load of chlordane and PCBs in the river so that the water quality criteria are not exceeded. Strategies to identify sites with elevated levels of chlordane and PCBs may be helpful for implementing controls to prevent the contaminants from being released into the river. As less of the contaminants become biologically available the concentrations of chlordane and PCBs measured in fish tissue samples should theoretically decline. Most importantly, continued fish tissue monitoring is advised to ensure that contamination decreases as time passes. This will help determine if additional loading is occurring.

8.3 Evaluation of TMDL Effectiveness

The effectiveness of these TMDLs will be assessed within the context of the State of Tennessee's rotating Watershed Approach. The Watershed Approach is based on a five-year cycle and encompasses planning, monitoring, assessment, TMDLs, WLAs/LAs, and permit issuance (ref.: http://www.state.tn.us/environment/wpc/watershed/). Watershed monitoring and assessment activities will provide information by which the effectiveness of chlordane and PCB load allocations can be evaluated. Continued fish tissue sampling will be necessary to monitor the efficacy of the proposed TMDLs. These TMDLs will be reevaluated during subsequent watershed cycles and revised as required to assure attainment of applicable water quality standards.

9.0 PUBLIC PARTICIPATION

In accordance with 40 CFR §130.7, the proposed TMDLs for chlordane and PCBs in the Wolf River was placed on Public Notice for a 35-day period and comments were solicited. Steps taken in this regard include:

1) Notice of the proposed TMDLs were posted on the Tennessee Department of Environment and Conservation website. The notice invited public and stakeholder comments and provided a link to a downloadable version of the TMDL document.

2) Notice of the availability of the proposed TMDLs (similar to the website announcement) was included in one of the NPDES permit Public Notice mailings, which wwere sent to interested persons or groups who have requested this information.

3) A letter was sent to identified water quality partners in the Wolf River Watershed advising them of the proposed chlordane and PCB TMDLs, stating the document's availability on the TDEC website, and inviting comments. These partners include:

Natural Resources Conservation Service
Tennessee Department of Agriculture
Tennessee Water Sentinels
United States Army Corps of Engineers
United States Fish and Wildlife Service
United States Geological Survey
Wolf River Conservancy

4) A draft copy of the proposed TMDLs was sent to the following MS4s:

TNS075698	Bartlett
TNS075230	Collierville
TNS075337	Germantown
TNS077526	City of Lakeland
TNS068276	Memphis Municipal Separate Storm Sewer System
TNS075663	Shelby County
TNS077585	Tennessee Department of Transportation

10.0 FURTHER INFORMATION

Further information concerning Tennessee's TMDL program can be found on the Internet at the Tennessee Department of Environment and Conservation website:

http://www.state.tn.us/environment/wpc/tmdl/

Technical questions regarding these TMDLs should be directed to the following members of the Division of Water Pollution Control staff:

Vicki S. Steed, Watershed Management Section
E-mail: Vicki.Steed@state.tn.us

Bruce R. Evans, P.E., Watershed Management Section
Email: Bruce.Evans@state.tn.us

Sherry H. Wang, Ph.D., Watershed Management Section
E-mail: Sherry.Wang@state.tn.us

11.0 REFERENCES

ATSDR. 1994. *Toxicological Profile for Chlordane.* U.S. Department of Health and Human Services, Public Health Service, Agency for Toxic Substances and Disease Registry. May 1994.

TDEC. *The Results of Fish Tissue Monitoring in Tennessee 1992-1997.* State of Tennessee, Department of Environment and Conservation, Division of Water Pollution Control.

TDEC. 2004. *Rules of Tennessee Department of Environment and Conservation.* Tennessee Water Quality Control Board, Division of Water Pollution Control, Chapter 1200-4-3 General Water Quality Criteria, January 2004.

TDEC. 2004a. *Bacteriological and Fishing Advisories in Tennessee.* Tennessee Department of Environment and Conservation, Division of Water Pollution Control.

TDEC. 2006. *Final Version, Year 2006 303(d) List.* State of Tennessee, Department of Environment and Conservation, Division of Water Pollution Control, December 2006.

USEPA. 1980. *Ambient Water Quality Criteria for Chlordane.* U.S. Environmental Protection Agency, Office of Water Regulation and Standards, Criteria and Standards Division, Washington, DC. EPA 440/5-80-027, October 1980.

USEPA. 1980a. *Ambient Water Quality Criteria for Polychlorinated Biphenyls.* U.S. Environmental Protection Agency, Office of Water Regulation and Standards, Criteria and Standards Division, Washington, DC. EPA 440/5-80-068, October 1980.

USEPA. 1983. *Amendments to National Oil and Hazardous Substance Contingency Plan; National Priorities List.* Federal Register Vol. 48, No. 175, September 8, 1983.

USEPA. 1983a. *NPL Site Narrative for North Hollywood Dump.* U.S. Environmental Protection Agency website: http://www.epa.gov/superfund/sites/nplsnl/n0403873.pdf

USEPA. 1991. *Guidance for Water Quality-based Decisions: The TMDL Process.* U.S. Environmental Protection Agency, Office of Water, Washington, DC. EPA-440/4-91-001, April 1991.

USEPA. 1992. *NPL Site Narrative for Memphis Defense Depot (DLA).* U.S. Environmental Protection Agency website: http://www.epa.gov/superfund/sites/nplsnl/n0404159.pdf

USEPA. 1994. *Water Quality Standards Handbook: Second Edition.* U.S. Environmental Protection Agency, Office of Water, Washington, DC. EPA 823-B-94-005a, August 1994.

USEPA. 1997. *Ecoregions of Tennessee*. U.S. Environmental Protection Agency, National Health and Environmental Effects Research Laboratory, Corvallis, Oregon. EPA/600/R-97/022.

USEPA. 1997a. *Toxicological Review of Chlordane (Technical) (CAS No. 12789-03-6) In Support of Summary Information on the Integrated Risk Information System (IRIS).* U.S. Environmental Protection Agency, Washington, DC. December 1997.

USEPA. 1999. *Fact Sheet: Polychlorinated Biphenyls (PCBs) Update: Impact on Fish Advisories*. U.S. Environmental Protection Agency, Office of Water, Washington, DC. EPA-823-F-99-019, September 1999.

USEPA. 1999a. *Water Quality Standards; Establishment of Numeric Criteria for Priority Toxic Pollutants; States' Compliance – Revision of Polychlorinated Biphenyls (PCBs) Criteria; Final Rule.* Federal Register Vol. 64, No.216, November 9, 1999.

USEPA. 2000. *Methodology for Deriving Ambient Water Quality Criteria for the Protection of Human Health (2000) Technical Support Document Volume 2: Development of National Bioaccumulation Factors.* U.S. Environmental Protection Agency, Office of Science and Technology, Office of Water, Washington, DC. EPA –822-R-03-030, December 2003.

USEPA. 2000a. *Revisions to Methodology for Deriving Ambient Water Quality Criteria for the Protection of Human Health (2000); Notice.* Federal Register Vol. 65, No. 214, November 3, 2000.

USEPA. 2002. *Toxic Pollutant Effluent Standards.* Title 40 Code of Federal Regulations, Pt. 129, July 1, 2002.

USEPA. 2006. *National Recommended Water Quality Criteria.* U.S. Environmental Protection Agency, Office of Water, Office of Science and Technology.

USEPA. 2007. *Tennessee NPL/NPL Caliber Cleanup Site Summaries North Hollywood Dump.* U.S. Environmental Protection Agency website: http://www.epa.gov/region4/waste/npl/npltn/norholtn.htm

USEPA. 2007a. *Tennessee NPL/NPL Caliber Cleanup Site Summaries USA Defense Depot Memphis.* U.S. Environmental Protection Agency website: http://www.epa.gov/region4/waste/npl/npltn/memdeftn.htm

USFDA. 2002. *Unavoidable Contaminants in Food for Human Consumption and Food-Packaging Material.* Title 21 Code of Federal Regulations, Pt.109, April 1, 2002.

APPENDIX A

Development of Water Quality Criteria for Chlordane

FRESHWATER AQUATIC LIFE CRITERIA

The U.S. Environmental Protection Agency lists freshwater aquatic life criteria for chlordane in *National Recommended Water Quality Criteria* (USEPA, 2006). Two components of the aquatic life criteria were published:

> The Criteria Maximum Concentration (CMC) is an estimate of the highest concentration of a material in surface water to which an aquatic community can be exposed briefly without resulting in an unacceptable effect. The Criterion Continuous Concentration (CCC) is an estimate of the highest concentration of a material in surface water to which an aquatic community can be exposed indefinitely without resulting in an unacceptable effect.

These criteria are intended for broad application, but "are intended to be protective of the vast majority of the aquatic communities in the United States" (USEPA, 2006).

Criterion Continuous Concentration

The CCC is based on criterion published in *Ambient Water Quality Criteria for Chlordane* (USEPA, 1980) where the Final Residue Value procedure was utilized:

> The Freshwater Final Residue Value is derived by dividing the FDA action level of 0.3 mg/kg by the geometric mean of the normalized BCF values (4,702) and by a percent lipid value of 15 for freshwater species.

The Tennessee Department of Environment and Conservation has adopted the current national recommended criteria as the statewide water quality criteria for chlordane under the fish & aquatic life designated use classification (TDEC, 2004). For the purpose of developing this chlordane TMDL, the freshwater aquatic life criterion continuous concentration was found to be the most stringent. Therefore, existing water column concentrations of chlordane were calculated in a manner that reflected the methodology utilized in developing the national criteria:

$$C_{water} = \frac{C_{fish}}{(4{,}702 \times 15)} \times 1{,}000$$

Where C_{water} = Water column concentration (µg/L)
C_{fish} = Fish tissue concentration (mg/kg)
4,702 = Geomean of normalized BCF values (L/kg)
15 = Percent lipid (freshwater species)
1,000 = Conversion factor (µg/mg)

The State of Tennessee recognizes, as noted in *National Recommended Water Quality Criteria* (USEPA, 2006), "Since the publication of the Great Lakes Aquatic Life Criteria Guidelines in 1995 (60FR15393-15399, March 23, 1995), the Agency no longer uses the Final Residue Value procedure for deriving CCCs for new or revised 304(a) aquatic life criteria. Therefore, the Agency anticipates that future revisions of this CCC will not be based on the FRV procedure". Consequently, future TMDLs will consider subsequent revisions made to national/state water quality criteria.

HUMAN HEALTH CRITERIA

The human health criteria also needed to be considered when developing the TMDLs because a fish consumption advisory was issued for chlordane contamination. To protect human health, limits for chlordane in the consumption of water & organism and organism only are presented in *National Recommended Water Quality Criteria* (USEPA, 2006). The U.S. Environmental Protection Agency recommends a water quality limit of 0.00080 µg/L of chlordane for the consumption of water & organism and 0.00081 µg/L for organism only (USEPA, 2006). These values are calculated according to a 10^{-6} risk level. The State of Tennessee assumes a 10^{-5} risk level and, under the recreation designated use classification, the corresponding criteria are 0.0080 µg/L for water & organism and 0.0081 µg/L for organism only. In order to determine deviations from the target value, it was necessary to compute the existing concentrations according to the methodology utilized when setting the state and/or national criteria. Therefore, the water column concentrations were also predicted using the weighted average Bioconcentration Factor [normalized BCF value (4,702) and "an adjustment factor of 3…[to account for]…the 3.0 percent lipids that is the weighted average for consumed fish and shellfish" (USEPA, 1980)]:

$$C_{water} = \frac{C_{fish}}{(14{,}100)} \times 1{,}000$$

Where C_{water} = Water column concentration (µg/L)
C_{fish} = Fish tissue concentration (mg/kg)
14,100 = Weighted average BCF (L/kg)
1,000 = Conversion factor (µg/mg)

Table A-1 lists the water column concentrations of chlordane predicted using the human health consumption methodology. The predicted water column concentrations were compared to the more stringent of the applicable State of Tennessee water quality criteria under the recreation designated use and none of the samples were found to exceed the criterion. The TMDLs were established using the fish & aquatic life criteria, which proved to be more stringent than either of the limits set by the State of Tennessee to protect human health (ref.: Section 4.0).

Table A-1 Estimated Concentration of Chlordane According to Human Health Criteria

Fish Species	Sample Year	Sampling Site Location	Total Chlordane in Fish Sample (ppm)	Calculated Water Column Concentration (µg/L)
Carp Sucker	2006	Highway 51	0.119	0.008
Channel Catfish			0.048	0.003

APPENDIX B

Development of Water Quality Criteria for PCBs

CARCINOGENIC RISK LEVEL

According to Section 304(a) of the Clean Water Act, the U.S. Environmental Protection Agency presented three separate criteria for carcinogens at risk levels corresponding to 10^{-7}, 10^{-6}, and 10^{-5} in the 1980 *Ambient Water Quality Criteria for Polychlorinated Biphenyls* (USEPA, 1980a). Within select sections of the 2000 Human Health Methodology (USEPA, 2000a), the U.S. EPA states:

> Both 10^{-6} and 10^{-5} are appropriate targets for health protection of the general population and that highly exposed populations should not exceed a 10^{-4} risk level. The incremental cancer risk levels are *relative*, meaning that any given criterion associated with a particular cancer risk level is also associated with specific exposure parameter assumptions (*i.e.,* intake rates, body weights). EPA recommends adoption of water quality standards that include water quality criteria based on either the 10^{-5} or 10^{-6} risk level if the State or authorized Tribe has identified the most highly exposed subpopulation, has demonstrated that the chosen risk level is adequately protective of the most highly exposed subpopulation, and has completed all necessary public participation. States and authorized Tribes also have flexibility in how they demonstrate this protectiveness and obtain such information. A State or authorized Tribe may use existing information as well as collect new information in making its determination as to an appropriate level of protection.

The Tennessee Department of Environment and Conservation, Division of Water Pollution Control designates a 10^{-5} risk level for all carcinogenic pollutants. A public fishing advisory will be considered when the calculated risk of additional cancers exceeds 10^{-4} for typical consumers or 10^{-5} for atypical consumers. (TDEC, 2004).

Human Health Criteria for Carcinogenic Pollutants

U.S. Environmental Protection Agency has developed equations for deriving human health criteria for carcinogenic pollutants. As published in *Water Quality Standards; Establishment of Numeric Criteria for Priority Toxic Pollutants; States' Compliance – Revision of Polychlorinated Biphenyls (PCBs) Criteria; Final Rule* (USEPA, 1999a), the human health criterion for organism and water consumption is as follows:

$$HHC = \frac{R \times W}{q \times [WC + (FC \times BCF)]} \times 1{,}000$$

Similarly, the human health criterion for organism only consumption is listed below:

$$HHC = \frac{R \times W}{q \times FC \times BCF} \times 1{,}000$$

Where HHC = Human health criterion (µg/L)
R = Risk Level
W = Human Body Weight (kg)
q = Cancer Slope Factor $(mg/kg \cdot day)^{-1}$
WC = Water Consumption (L/day, applicable to drinking water supply)
FC = Fish Consumption (kg/day)
BCF = Bioconcentration Factor (L/kg)
1,000 = Conversion Factor (µg/mg)

State Water Quality Criteria for PCBs

National recommended water quality criteria are published pursuant to Section 304(a) of the Clean Water Act. The national criteria provide guidance for states to use when adopting water quality standards. EPA's current national recommended water quality criteria for PCBs equal 0.000064 µg/L for both organism only and water & organism designations. These values were derived using the above equations for Human Health Criteria when, as listed in the 1999 PCB Criteria (USEPA, 1999a) and updated in the 2000 Human Health Methodology revision (USEPA, 2000a):

$R = 1x10^{-6}$
W = 70 kg
$q = 2\ (mg/kg{\cdot}day)^{-1}$
WC = 2 L/day
FC = 0.0175 kg/day
BCF = 31,200 L/kg

Because the State of Tennessee sets the plausible-upper-limit risk of cancer associated with PCBs at the 10^{-5} risk level, the corresponding state water criteria are 0.00064 µg/L (http://www.epa.gov/waterscience/criteria/wqcriteria.html). For the purposes of these TMDLs, the state water quality criteria for PCBs were used to determine the target value.

APPENDIX C

PUBLIC NOTICE ANNOUNCEMENT

STATE OF TENNESSEE
DEPARTMENT OF ENVIRONMENT AND CONSERVATION
DIVISION OF WATER POLLUTION CONTROL

PUBLIC NOTICE OF AVAILABILITY OF PROPOSED TOTAL MAXIMUM DAILY LOAD (TMDLS) FOR CHLORDANE & POLYCHLORINATED BIPHENYLS FOR WOLF RIVER IN THE WOLF RIVER WATERSHED (HUC 08010210), TENNESSEE

Announcement is hereby given of the availability of Tennessee's proposed Total Maximum Daily Loads (TMDLs) for chlordane and polychlorinated biphenyls (PCBs) for the Wolf River in the Wolf Watershed, located in western Tennessee. Section 303(d) of the Clean Water Act requires states to develop TMDLs for waters on their impaired waters list. TMDLs must determine the allowable pollutant load that the water can assimilate, allocate that load among the various point and nonpoint sources, include a margin of safety, and address seasonality.

Wolf River was identified on Tennessee's Final 2006 303(d) list as not supporting designated use classifications due to elevated levels of chlordane and polychlorinated biphenyls (PCBs) in fish tissue samples. Contaminated sediments are the source of pollutant causes associated with both impairments. Using a mass-balance approach, the TMDLs utilize Tennessee's general water quality criteria, fish tissue sampling data collected from Wolf River, Bioconcentration Factors defined by the U.S. Environmental Protection Agency, and an appropriate Margin of Safety (MOS) to establish chlordane and PCB loading levels which will result in lower fish tissue concentrations and the attainment of water quality standards.

The proposed chlordane and PCB TMDLs may be downloaded from the Department of Environment and Conservation website:

http://www.state.tn.us/environment/wpc/tmdl/

Technical questions regarding this TMDL should be directed to the following members of the Division of Water Pollution Control staff:

Vicki S. Steed, P.E., Watershed Management Section
Telephone: 615-532-0707

Bruce R. Evans, P.E., Watershed Management Section
Telephone: 615-532-0668

Sherry H. Wang, Ph.D., Watershed Management Section
Telephone: 615-532-0656

Persons wishing to comment on the proposed TMDL are invited to submit their comments in writing no later than November 12, 2007 to:

Division of Water Pollution Control
Watershed Management Section
7th Floor, L & C Annex
401 Church Street
Nashville, TN 37243-1534

All comments received prior to that date will be considered when revising the TMDL for final submittal to the U.S. Environmental Protection Agency.

The TMDL and supporting information are on file at the Division of Water Pollution Control, 6th Floor, L & C Annex, 401 Church Street, Nashville, Tennessee. They may be inspected during normal office hours. Copies of the information on file are available on request.